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# Chase Brass & Copper Co.

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**Waterbury, Connecticut**

D. K. CRAMPTON
DIRECTOR OF RESEARCH
B. H. McGAR
ASST DIRECTOR OF RESEARCH

CHASE

August 28, 1936.

G. F. Jenks,
Col., Ord. Dept.,
War Department,
Watertown Arsenal,
Watertown, Mass.

Dear Colonel Jenks:-

We have your letter of August 21st and the copy of report No. 342/223 covering comparison of aluminum, silicon and beryllium tin bronzes on which you ask for comment.

As olympic bronze which is mentioned by name in this report is our own particular type of silicon bronze, we are naturally much interested in results of the tests given in this report. Naturally we are much disappointed in the rather poor showing of this material in comparison with the others tested. After studying carefully into conditions of preparation and testing, we believe the test values probably are somewhat misleading.

The alloy is used in the condition as sand cast in which condition it shows properties not at all comparable to those found in the wrought materials in which condition they are usually produced. Further, the conditions of casting, particularly the temperature of pouring of the metal, have a profound effect on the physical properties. Apparently the particular bar had been cast at a rather high temperature resulting in a very course, weak structure. Very much better properties would probably have been found had a lower pouring temperature been used.

Further, it is noted that while the bar was made approximately 1-1/2" in diameter, the tensile test specimen had been turned to 0.505" diameter so that a small proportion of the whole original section was tested and unfortunately that portion, which was probably the poorest and perhaps the least sound.

It is hoped that the logic of the above comments will be accepted and the values reported not be taken as typical of what this material should show.

Very truly yours,

CHASE BRASS & COPPER CO.

D. K. Crampton

D. K. Crampton.
FBW

Research Director.

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Report No. 342/223
Watertown Arsenal July 22, 1936

## Comparison of Al, Si, Be, and Sn Bronzes

### Object

To compare properties and corrosion resistance of special aluminum (Ampco 18), special silicon (Olympic) beryllium and tin bronzes.

### Reference

X.O. 624-A2

### Conclusions

The order of decreasing tensiles strengths observed was beryllium bronze, ampco 18, tin bronze, olympic bronze. The order of decreasing corrosion resistance to synthetic sea salt spray was ampco 18, beryllium bronze, tin bronze, olympic bronze.

When coupled with monel metal and CRS1 (18/8 stainless alloy) in synthetic sea water, negligible galvanic currents were observed.

Aluminum bronzes appear to be a suitable substitute for tin (Phosphor) bronze which is harder and probably more corrosion resistant. Beryllium bronzes are harder and of equal corrosion resistance and probably more expensive. The sample of olympic bronze was probably poorly processed.

## Introduction

Engineers desired a bronze which was harder than tin (phosphor) bronze for certain uses. The corrosion resistance had to be equal to that of tin bronze. Ampco metal was chosen for test. Olympic bronze was on hand and parallel tests were carried out with it.

## Material

The analyses of the material tested are given on table I.

## Tensile Properties

The results of tension and impact tests are given on table II.

## Corrosion Resistance

Behavior in synthetic sea salt spray is recorded in table III.

The behavior wherin galvanic contact with monel and 18/8 stainless alloy - CRS1 - in synthetic sea water is recorded in table IV. The test method was that reported in W.A. 780/1 and consisted of shorting the couples and periodically inserting a milliammeter in the circuit.

## Discussion

Ampco metal, a product of Ampco Metal Inc., Milwaukee, Wisconsin, is a copper aluminum iron alloy, containing from 9% Al, 3% Fe to 13% Al 4% Fe according to the grade.

The physical properties claimed for grade 18 are:

| | |
|---|---|
| Tensile Strength | 77,000/85,000#/sq.in. |
| Yield Point | 37,000/42,000 " |
| Elongation | 10-14% |
| Reduction in Area | 6-10% |
| $BHN_{3000}$ | 167-179 |
| $100^{R}_{B}$ | 85-87 |

These compare favorably with observed properties.

Local experience with similar castings indicates same order of magnitude of properties are readily obtainable. By increasing the alloy content strength is obtained at a sacrifice in ductility. The various grades available in Ampco are listed in the appendix.

The beryllium copper alloy was received in the soft condition from Ampco Metals Inc. ($_{100}R_B$ 54, BHN 89). It was then hardened by heating to 570°F (300°C) for 2 hours and furnace cooling. The hardness was raised to $_{150}R_C$ 36 - BHN 340/360.

The olympic bronze did not have as high physical properties as expected. The test bar was cut from a cast 1-1/2" round rod. The metal appeared coarse. It is evident that the observed properties are not representative and the sample was improperly processed.

Respectfully submitted,

P R Kosting

P. R. Kosting,
Chemical Engineer.

## TABLE I

Report No. 342/298

Sample from Dr. Kosting, Ex. O. 624-A2

| Mark | A<br>3" dia. | B<br>3" dia. | C<br>1" dia. | D<br>1-1/2" dia. | E<br>3" dia. |
|---|---|---|---|---|---|
| Tin | Nil | Nil | Nil | Nil | 3.625 |
| Copper | 97.20 | 85.50 | 85.65 | 94.00 | 95.95 |
| Nickel | .35 | .17 | .18 | Nil | Nil |
| Manganese | Nil | .015 | .02 | Nil | Nil |
| Phosphorus | .006 | Trace | Nil | Nil | .345 |
| Iron | .24 | 4.06 | 3.60 | .18 | .06 |
| Aluminum | Nil | 10.26 | 10.55 | .10 | Trace |
| Lead | Nil | Nil | Nil | Nil | Nil |
| Zinc | Nil | Nil | Nil | .97 | Nil |
| Silicon | - | - | - | 4.75 | - |
| Beryllium | 2.20 | - | - | - | - |

A - Be Bronze Cent. Casting - Ampco Product
B - Al " " " Ampco Grade 18
C - Al " Sand " " " "
D - Si " " " Olympic Bronze
E - Sn " Rod

A. Sloan,
Chemist.

TABLE II

Report No. 342/483

STUDY OF BRONZES

Tensile Properties

June 18, 1936

| Specimen Mark | Dia. inches | Y.S. 0.00% set #/sq. in. | Y.S. 0.2% set #/sq. in. | T.S. | Elong.% | Red. of Area % | Break | Fracture |
|---|---|---|---|---|---|---|---|---|
| A1 | .113 | 114,000 | --- | 136,500 | 2.5 | 3.2 | middle third | Irregular pitted dendritic |
| A2 | | X | X | 136,000 | 2.5 | 1.5 | " | " " " |
| B1 | .113 | X | X | 78,000 | 10.0 | 13.5 | at gage mark | 90° finely pitted |
| B2 | | X | X | 83,000 | 10.0 | 3.3 | " | " " |
| C | .357 | curved | curved | 84,600 | 9.3 | 7.6 | at gage mark | 90° finely pitted, segregated checks on stem |
| D | .505 | curved | curved | 28,750 | 4.5 | 8.8 | outer third | Irregular 90°, pitted, segregated coarsely dendritic cracks on stem |
| E1 | .113 | X | X | 54,500 | 32.5 | 76.3 | middle third | Partial cup, pitted, checks & cracks on stem near break. |
| E2 | .113 | 48,000 | 54,000 | 55,000 | 26.0 | 59.3 | " | |

A = Be copper centrifugal casting - Ampco product

B = Aluminum Bronze centrifugal casting - Ampco product Grade 18

C = Aluminum Bronze Sand Casting - Ampco product Grade 18

D = Si Bronze Sand Casting - Olympic Bronze

E = Sn Bronze Rod

X = not observed

Impact-tensile notched Charpy

| Specimen No. | Ft. Lbs. | Fracture |
|---|---|---|
| C1 | 9.2 | Irregular break, spongy, pitted, segregated. |
| D1 | 27.6 | Irregular break, coarsely pitted, segregated, coarsely dendritic. |
| D2 | 21.1 | Irregular break, coarsely pitted, segregated, coarsely dendritic. |
| E | 18.1 | Pitted, coarse. |

D. E. Driscoll

Rockwell B Hardness

| | A | B | C | D | E |
|---|---|---|---|---|---|
| $100^{R}B$ | 115 | 90 | 88-1/2 | 65 | 76 |

TABLE III

STUDY OF BRONZES

Synthetic Sea Salt Spray Resistance

| Metal | Spec. No. | Wgt. Ave. | Gain or Loss Mg. | | Time Exposed Hrs. | Surface Finish | Appearance |
|---|---|---|---|---|---|---|---|
| | | | Mx. | Mn. | | | |
| A | 1-2-3 | -1.5 | -2.2 | -1.6 | 147 | 00 emery | Bluish, uniform attack |
| | | -1.5 | -2.2 | -0.6 | 184 | Corroded | " 90% uniform |
| | 4-5-6 | -1.9 | -2.3 | -1.7 | 213 | 00 emery | " uniform |
| | | -2.4 | -2.7 | -2.3 | 184 | Corroded | " 90% uniform |
| | | -2.0 | -2.7 | -0.6 | 184 | Corroded Rating | |
| B | 1-2-3 | -0.1 | -0.3 | -0.0 | 147 | 00 emery | Irregular spotting, rough |
| | | -0.1 | -0.3 | +0.1 | 184 | Corroded | Mottled 60% rough |
| | 4-5-6 | +0.8 | +0.3 | +1.0 | 213 | 00 emery | Irregular spotting, rough |
| | | +0.2 | -0.2 | +0.7 | 184 | Corroded | Mottled 60% rough |
| | | +0.1 | -0.3 | +0.7 | 184 | Corroded Rating | |
| C | 1 & 2 | -0.3 | -0.3 | -0.3 | 147 | 00 emery | Irregular spotting, rough |
| | | +0.3 | +0.3 | +0.2 | 184 | Corroded | Mottled 60% rough |
| | 3 & 4 | +0.4 | +0.4 | +0.3 | 213 | 00 emery | Irregular spotting, rough |
| | | +0.9 | +1.1 | +0.6 | 184 | Corroded | Mottled 60% rough |
| | | +0.6 | +1.1 | +0.2 | 184 | Corroded Rating | |
| D | 1-2-3 | +32.0 | +51.0 | +22.0 | 147 | 00 emery | Irregular encrustations |
| | | -5.6 | -9.3 | -0.8 | 184 | Corroded | " " |
| | 4-5-6 | +58.0 | +85.0 | +34.0 | 213 | 00 emery | " " |
| | | -40.0 | -62.0 | -23.0 | 184 | Corroded | " " |
| | | -23.0 | -62.0 | -0.8 | 184 | Corroded Rating | |

## TABLE III (Cont'd)

### Synthetic Sea Salt Spray Resistance

| Metal | Spec. No. | Wgt. Ave. | Gain or Loss Mg Mx. | Gain or Loss Mg Mn | Time Exposed Hrs. | Surface Finish | Appearance |
|---|---|---|---|---|---|---|---|
| E | 1-2-3 | -3.5 | -4.3 | -2.7 | 147 | 00 emery | Coppery |
| | | -4.1 | -6.3 | -1.2 | 184 | Corroded | Bluish 80% uniform smooth |
| | 4-5-6 | -3.3 | -3.7 | -3.0 | 213 | 00 emery | Coppery |
| | | -3.3 | -3.4 | -3.1 | 184 | Corroded | Bluish 80% uniform smooth |
| | | -2.7 | -6.3 | -1.2 | 184 | Corroded Rating | |

Rating

| | | | | | | | : | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface Finish | Corroded | | | | | | : | #00 emery | | | | |
| Time, hrs. | 184 | | | | | | : | 148 | | | | |
| Material-poor | D | E | A | B | C | best | : | E | A | C | B | D |
| Wt. Loss Mg. | -23 | -2.7 | -2.0 | +0.1 | +0.6 | | : | -3.5 | -1.5 | -0.3 | -0.1 | +32 |

| | | | | | |
|---|---|---|---|---|---|
| Surface Finish | #00 emery | | | | |
| Time, hrs. | 213 | | | | |
| Material-poor | E | A | C | B | D |
| Wt. Loss Mg. | -3.3 | -1.9 | +0.4 | +0.8 | +58.0 |

Aluminum Bronze may be considered slightly more corrosion resistant to synthetic sea salt spray than 3 1/2% tin bronzes and other bronzes with 96% copper or better in them.
Silicon bronze is definitely inferior to tin bronze.
Plumb bob specimen used, 1" high 0.55" cone, 0.25" body 0.10" recess, 0.10" base, 0.625" dia. of body.

Observers - W. Galvin and M.B. Gruzdis.

A = Be Copper C.C. C = Al Bronze Sand Casting E = Sn Bronze Rod
B = Al Bronze C.C. D = Si " " "

TABLE IV

STUDY OF BRONZES

Galvanic Behavior in Synthetic Sea Water

| | | | | | |
|---|---|---|---|---|---|
| Bronze | A | A | B | D | E |
| Spec # | 2 | 3 | 2 | 1 | 1 |
| Electrode Monel Metal # | 6 | 2 | 5 | 1 | 4 |
| Time, hrs. | Current | | m amps/sq.in. | | |
| 0 | .0025 | -.0040 | -.0030 | +.0050 | +.0060 |
| 1 | -.0004 | -.0018 | -.0038 | -.0012 | +.0002 |
| 96 | -.0030 | -.0022 | -.0050 | -.0021 | -.0020 |
| Anode | A | A | B | D | E |
| Wt.Loss Electrode Monel | 0 | 0 | 0.6 | 0.7 | 0.1 |
| in Mg Bronze | 10.1 | 2.0 | 13.8 | 11.9 | 3.5 |

| | | | | |
|---|---|---|---|---|
| Bronze | A | B | D | E |
| Spec. # | 1 | 1 | 3 | 2 |
| Electrode CRS #1 (18/8)# | 3 | 8 | 6 | 9 |
| Time, hrs. | Current | m amps/sq.in. | | |
| 0 | -.0040 | -.0060 | +.0170 | -.0015 |
| 1 | -.0018 | -.0023 | -.0015 | -.0018 |
| 96 | -.0010 | -.0018 | -.0016 | -.0020 |
| Anode | A | B | D | E |
| Wt.Loss Electrode CRS #1 | 0 | 0 | .5 | .1 |
| in Mg Bronze | 1.7 | .5 | 10.3 | 10.6 |

| | | | |
|---|---|---|---|
| Bronze | A | B | D |
| Spec. # | 6 | 3 | 2 |
| Electrode Bronze E # | 1 | 1 | 3 |
| Time, hrs. | Current | m amps/sq.in. | |
| 0 | -.0150 | -.0300 | -.0080 |
| 1 | -.0002 | -.0300 | -.0120 |
| 96 | -.0010 | -.0120 | -.0040 |
| Anode | A | B | D |
| Wt.Loss Electrode E | .7 | 3.4 | 1.7 |
| in Mg Bronze | 5.4 | 1.3 | 5.6 |

The order of magnitude of current that flowed is negligible except in case where tin bronze was coupled with Aluminum Bronze. Data is inconsistent.

Observer - M. B. Gruzdis

A = Be Copper C.C.
B = Al Bronze C.C.
C = Al Bronze Sand Casting
D = Si Bronze Sand Casting
E = Sn Bronze Rod

APPENDIX

TABLE I

GRADES OF AMPCO METAL

| Metal | Grade | Al % | Fe % | Tensile Strength 1000 psi | Yield Point 1000 psi | Elong. % | Red. in Area % | $BHN_{3000}$ | Rockwell | Applications |
|---|---|---|---|---|---|---|---|---|---|---|
| Ampco | 12 | 8.6 | 2.9 | 55/65 | 22/27 | 22/27 | 22/27 | 115/121 | 65/67 B | Bushings, light load - high speed: machine parts. |
| | 16 | 10.2 | 3.3 | 70/80 | 32/37 | 18/22 | 16/20 | 137/143 | 78/80 B | General bushing & bearing work, machine parts, pump parts. |
| | 18 | 11.3 | 3.7 | 77/85 | 37/42 | 10/14 | 6/10 | 167/179 | 85/87 B | Heavy duty bearings & gears, acid equipment. |
| | 20 | 12.4 | 4.1 | 83/90 | 40/43 | 4/6 | | 229/241 | 19/21 C | Cams, rollers, guide bushings, striking plates. |
| | 21 | 13.0 | 4.1 | 88/95 | 42/44 | 3-5 | | 285/302 | 32/34 C | Forming dies, slides. |
| | 22 | 13.4 | 4.4 | 93/100 | 42/45 | 1-4 | | 321/341 | 36/38 C | Forming dies for stainless steels. |